

下一代汽車雷達技術與演進發展

2021/04/15

TI Jesse Wang.



Agenda

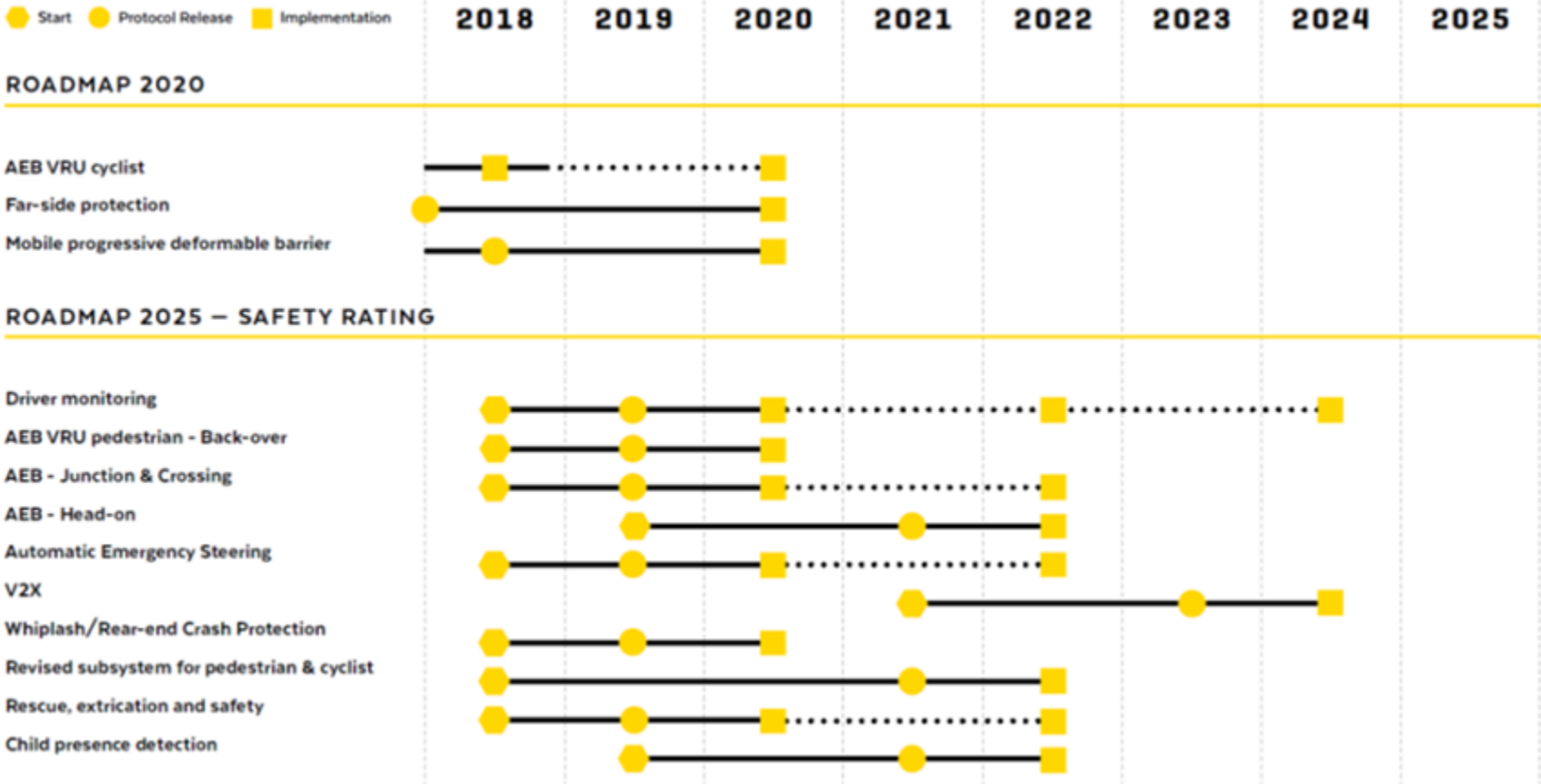
- Requirement for Driving Automation
- TI Development
 - Image Radar
 - Parking and Corner Radar
 - In-Cabin and Near-Field Radar

SAE – Levels of Driving Automation

	SAE LEVEL 0	SAE LEVEL 1	SAE LEVEL 2	SAE LEVEL 3	SAE LEVEL 4	SAE LEVEL 5
What does the human in the driver's seat have to do?	You are driving whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering			You are not driving when these automated driving features are engaged – even if you are seated in “the driver’s seat”		
	You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you must drive	These automated driving features will not require you to take over driving	
What do these features do?	These are driver support features			These are automated driving features		
	These features are limited to providing warnings and momentary assistance	These features provide steering OR brake/acceleration support to the driver	These features provide steering AND brake/acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met	This feature can drive the vehicle under all conditions	
	<ul style="list-style-type: none"> • automatic emergency braking • blind spot warning • lane departure warning 	<ul style="list-style-type: none"> • lane centering OR • adaptive cruise control 	<ul style="list-style-type: none"> • lane centering AND • adaptive cruise control at the same time 	<ul style="list-style-type: none"> • traffic jam chauffeur 	<ul style="list-style-type: none"> • local driverless taxi • pedals/steering wheel may or may not be installed 	<ul style="list-style-type: none"> • same as level 4, but feature can drive everywhere in all conditions
Example Features						

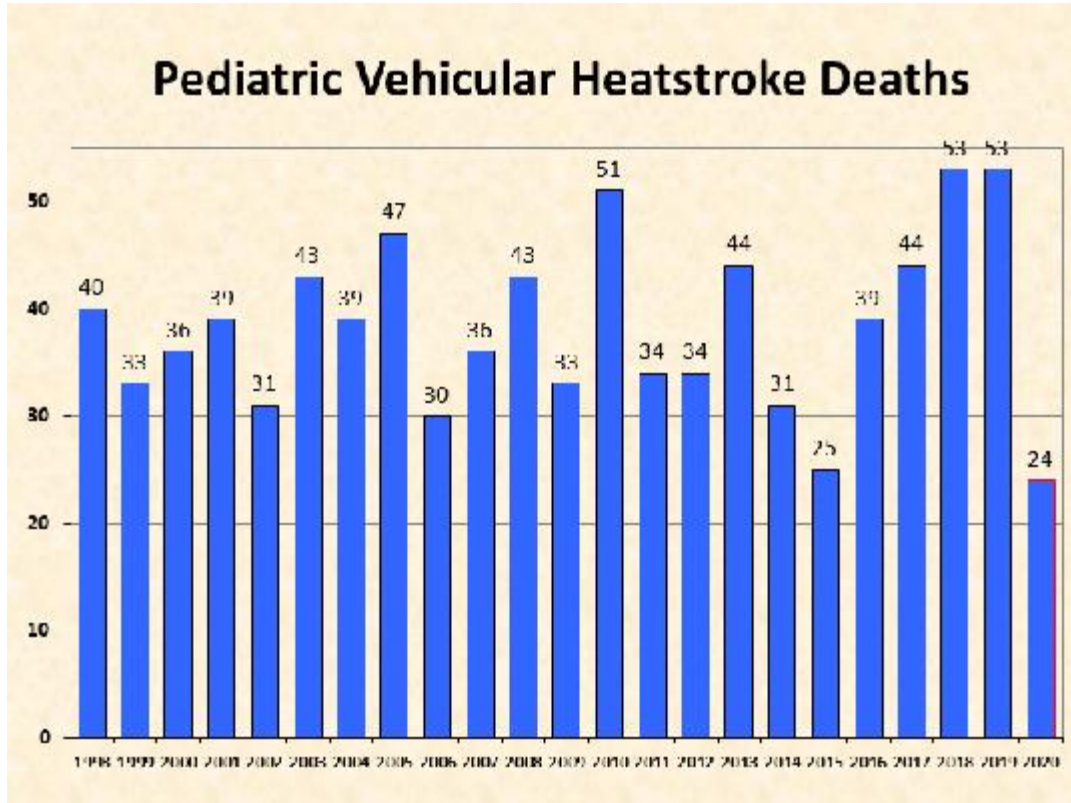
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OEM View – Euro NCAP 2025 Roadmap



Source from: <https://cdn.euroncap.com/media/30700/euroncap-roadmap-2025-v4.pdf>

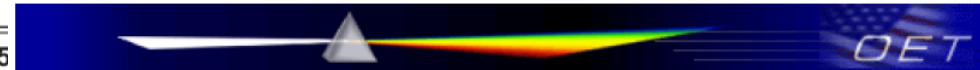
Need to Detect Unattended Child – US Example



- Report of the 849 pediatric vehicular heatstroke deaths for a 22-year period (1998 through 2020) shows the following circumstances:
 - 54.2% - Forgotten by caregiver (460 children)
 - 25.2% - Gained Access on their own (214)
 - 19.1% - Knowingly left by caregiver (162)
 - 1.5 % - Unknown (13)
- There are technologies can remind or warn us if a child is left in a vehicle.

mmWave Radar Regulatory Compliance Overview

	57Ghz	85GHz
USA FCC	57-71GHz - Short range devices for "Interactive motion Sensing" (e.g. Google Soli), Fixed installations at low power 61- 61.5GHz - Fixed installations at high power	75- 85GHz -Level probing radar (downward facing,narrow beam) 76 - 81GHz -Vehicular Radar, Airplane-Installed wing tip radar 76- 77GHz - FOD at airports, Fixed Infrastructure
Europe CE / RE D	57- 64GHz – Open, restrictions on output power Level Probing Radar, Tank level probing radar 61- 65GHz - Open, Reduced restrictions on ouput power	75- 85GHz - Level Probing Radar, Tank Level Probing Radar 76-77GHz - Vehicular Radar, Fixed Traffic Monitoring, Rail road crossings, Manned Rotorcraft 77- 81Ghz - Vehicular Radar
China SRRC / CCC	59- 64GHz - Open for radiolocation 61- 61.5GHz - Open according to ISM rules	76-77GHz - Vehicular Radar
Korea KCC / MSIP	57-66GHz - Open, but low output power (Rule Code : K176C 61-61.5Ghz - No Regulations so far, possibly open according to ISM rules	75-85 astror Satell 76-77 (Rule
Japan MIC / TELEC	60 - 61GHz - Open	



Federal Communications Commission
Office of Engineering and Technology
Laboratory Division

April 12, 2019

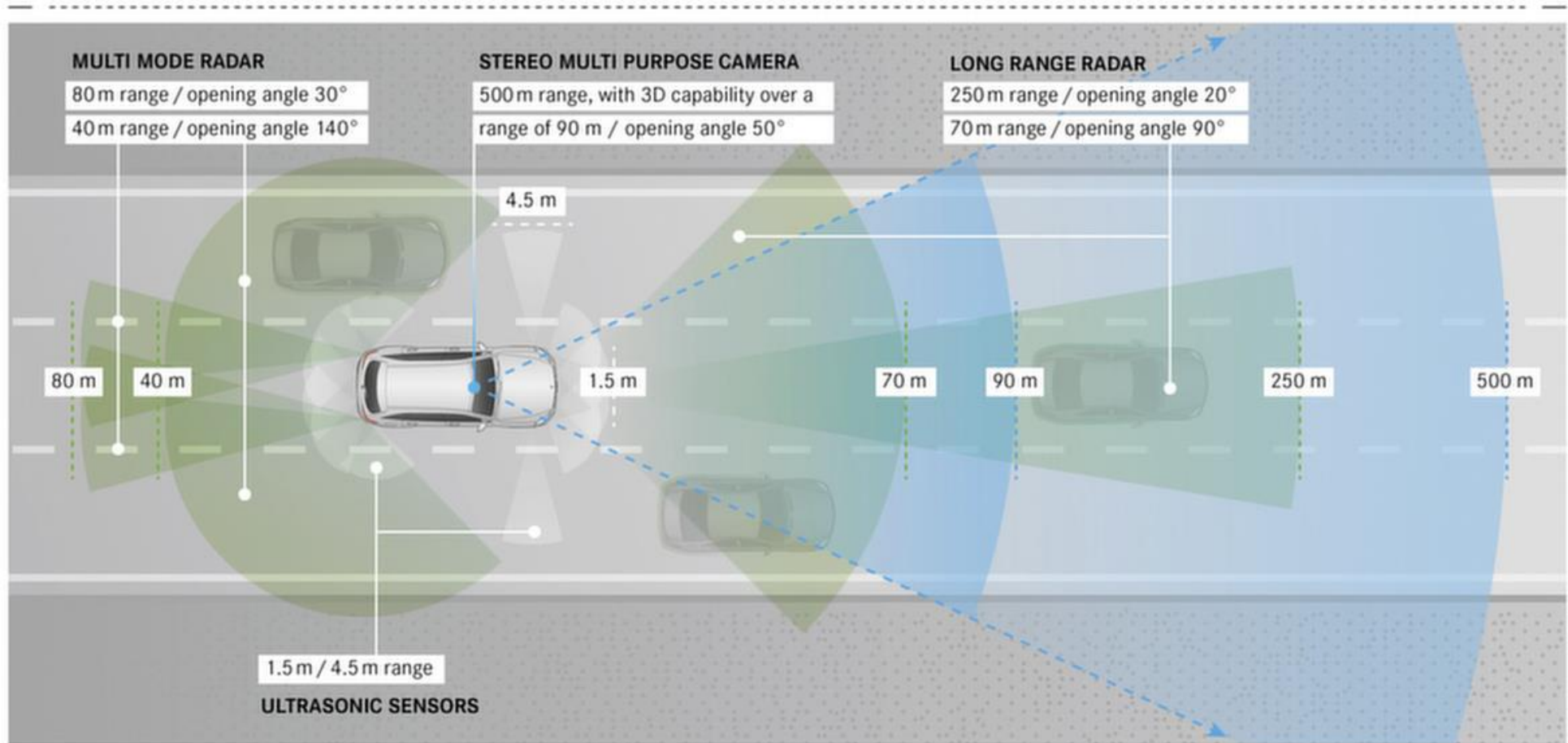
EQUIPMENT AUTHORIZATION GUIDANCE FOR 76-81 GHz RADAR DEVICES

³ Radar devices intended solely for automotive in-cabin usage are not permitted under these rules.

(continued...)

653005 D01 76-81 GHz Radars v01r01
Page 1

Example of automotive sensor

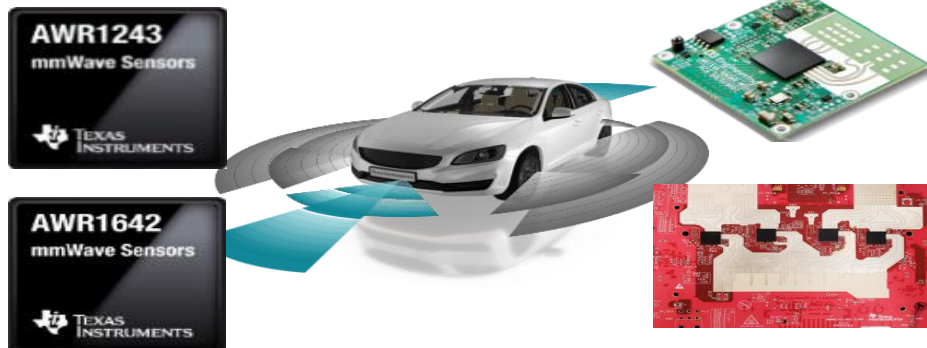


Schematic illustration, not to scale

Source from: https://www.caricos.com/cars/m/mercedes-benz/2020_mercedes-benz_eqc/images/93.html

Automotive Radar – Executive Summary

Innovation & Execution



- **CMOS MMIC Portfolio fully Auto Qualified including the 1st Single Chip Automotive Radar (AECQ100, ASIL-B)**
- **Portfolio of devices from integrated Front End to Single Chip w/ integrated Processing & standalone Radar MCU family**
- **2nd gen transceiver in Production, with performance ahead of SiGe**

Applications



Corner Radar



Imaging Radar



Automatic Parking



In-Cabin Sensing, Near-Field Sensing

Imaging Radar

Why Image Radar Is A Game Changer?

Overhead bridges/tunnels

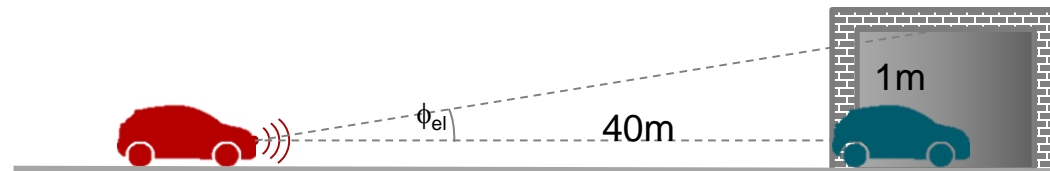


Today radar system is programmed to ignore high-mounted objects such as road signs and, possibly, the flanks of a semi truck, to avoid undesired braking events.

VIDEO: <http://www.ti.com/tool/TIDEP-01012#2>

BLOG: [Imaging radar: one sensor to rule them all](#)

High Elevation Angle Resolution with MIMO



e.g. static truck stalled under a bridge

Angle Resolution required - $\phi_{el} < 1.4^\circ$

High Azimuth Angle Resolution with MIMO



Two cars in adjacent lanes 100m range

Angle Resolution required - $\phi_{az} < 1.7^\circ$

Imaging Radar ~ 1° both Azimuth & Elevation

The Radar Sensor will become the **primary** sensor in the car

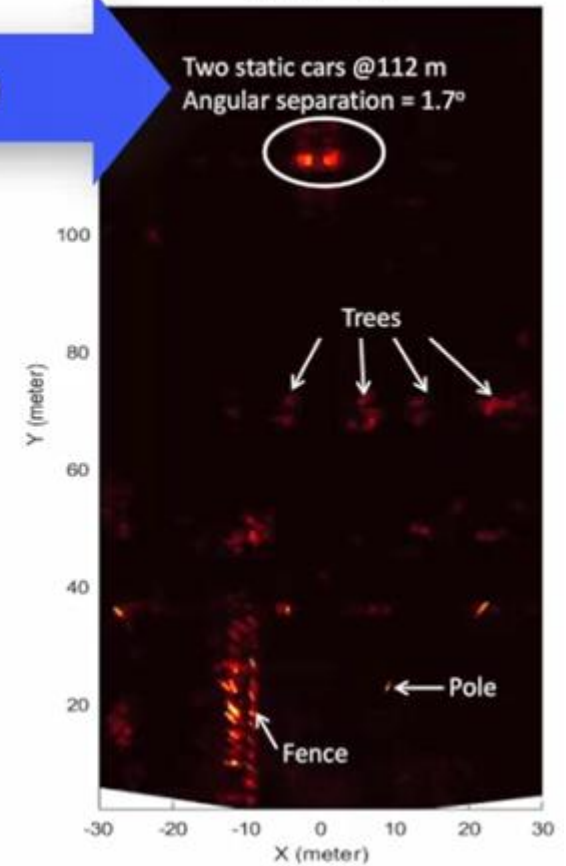
Radar Delivers Imaging

1.7° angular separation at 112 m

Camera View



Radar View

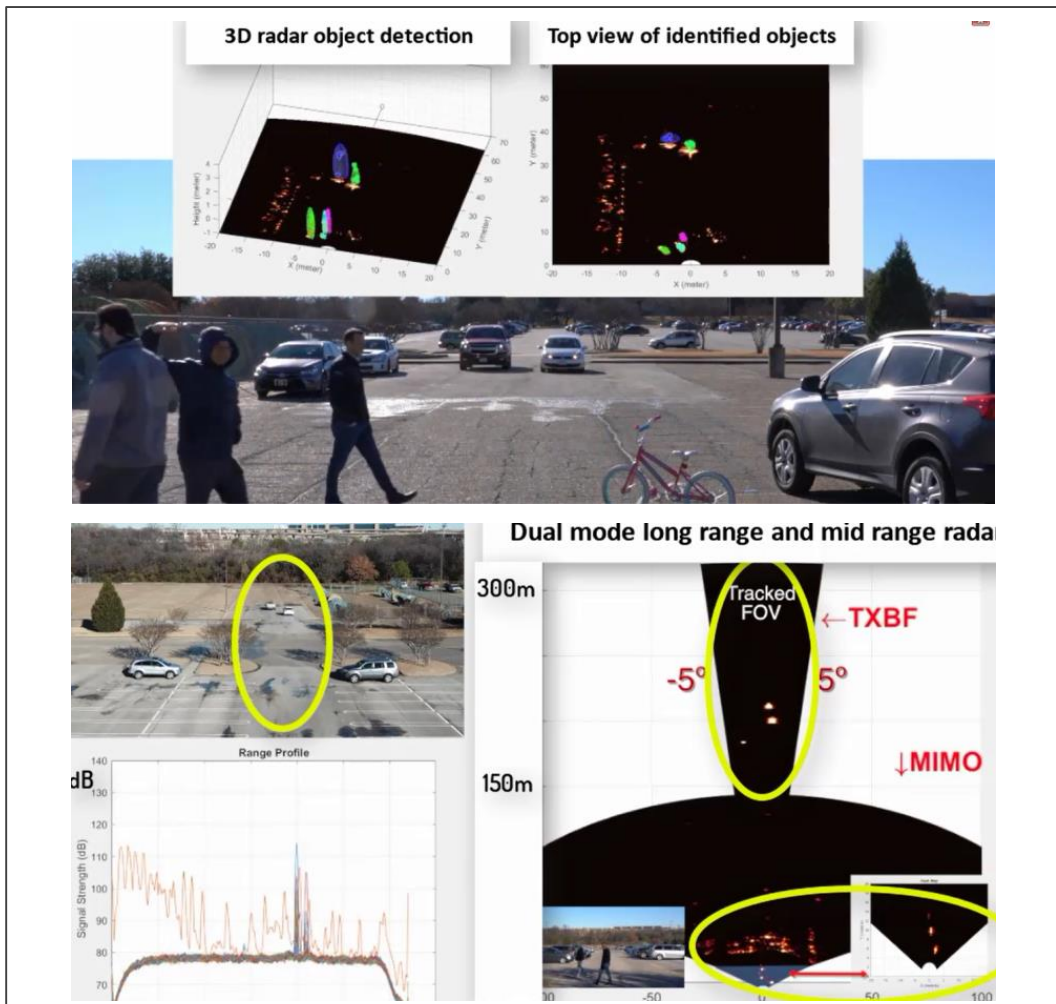


High Azimuth Angle Resolution with MIMO



Two cars in adjacent lanes 100m range
Angle Resolution required - $\phi_{az} < 1.7^\circ$

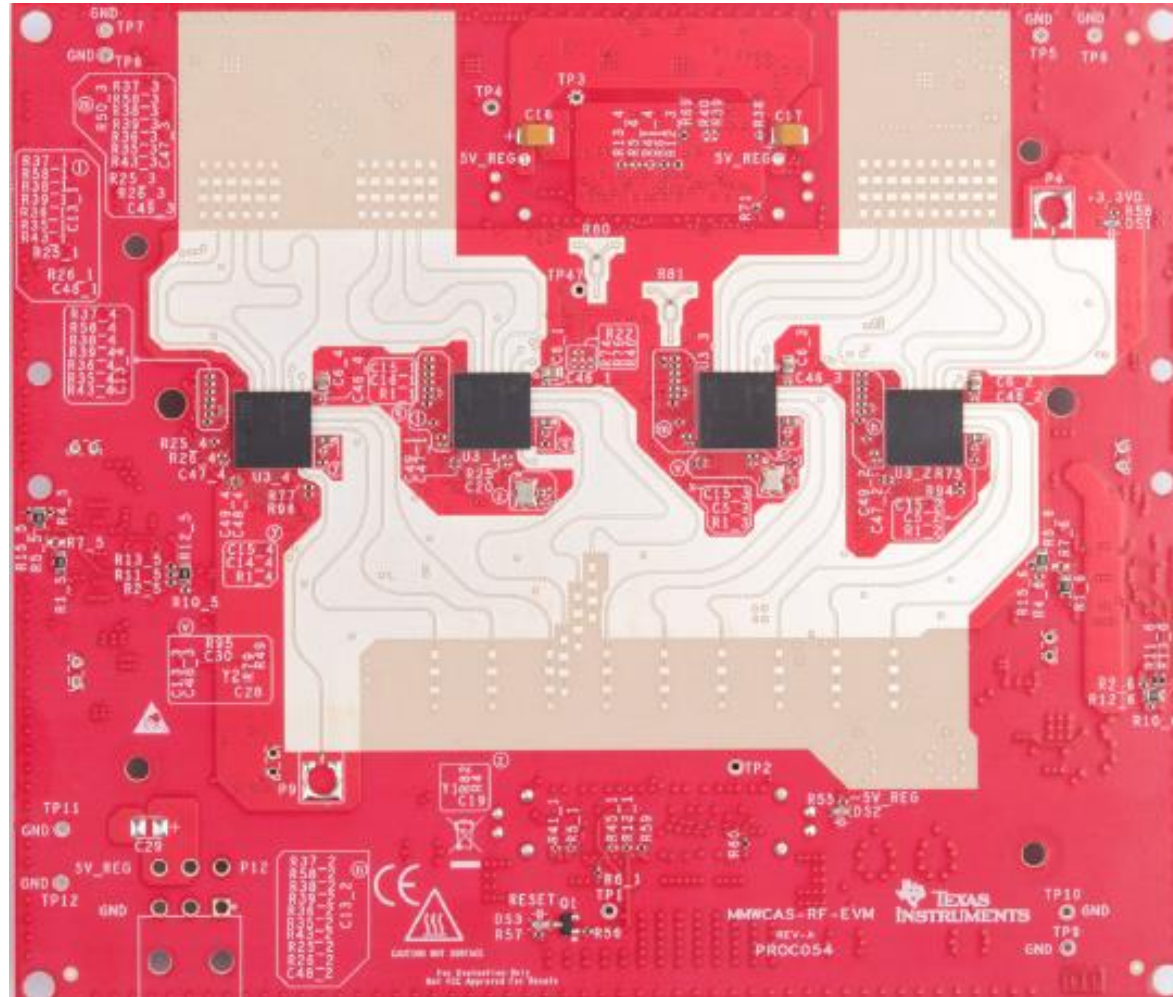
Imaging Radar – Cascaded High-Performance Front-End



Key Features

- **High performance and low power imaging radar with lowest BOM**
 - Lidar-like imaging performance, $<1^\circ$ angular resolution
 - 350m+ range for cars and 150m+ for pedestrians
 - Accurate beam steering for longer range object tracking
- **Simplified design with built-in cascade circuitry**
 - 2+ years of systems work to develop algorithms and design guides
 - Multi-channel antenna calibration for MIMO and beamforming
- [Imaging radar demonstration video](#)
- [TI Design – Imaging Radar](#)
- [AWR2243 - The highest-performance sensor for front radar](#)

To Start Imaging Radar – Development Kit

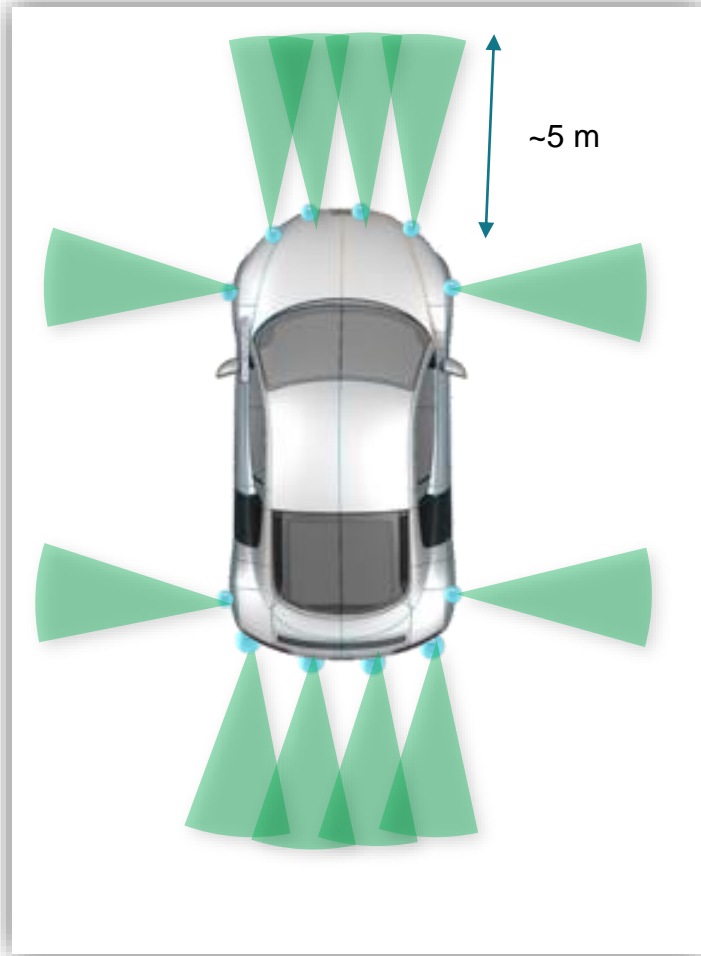


From: [TIDEP-01012](#)

13

Parking and Corner Radar

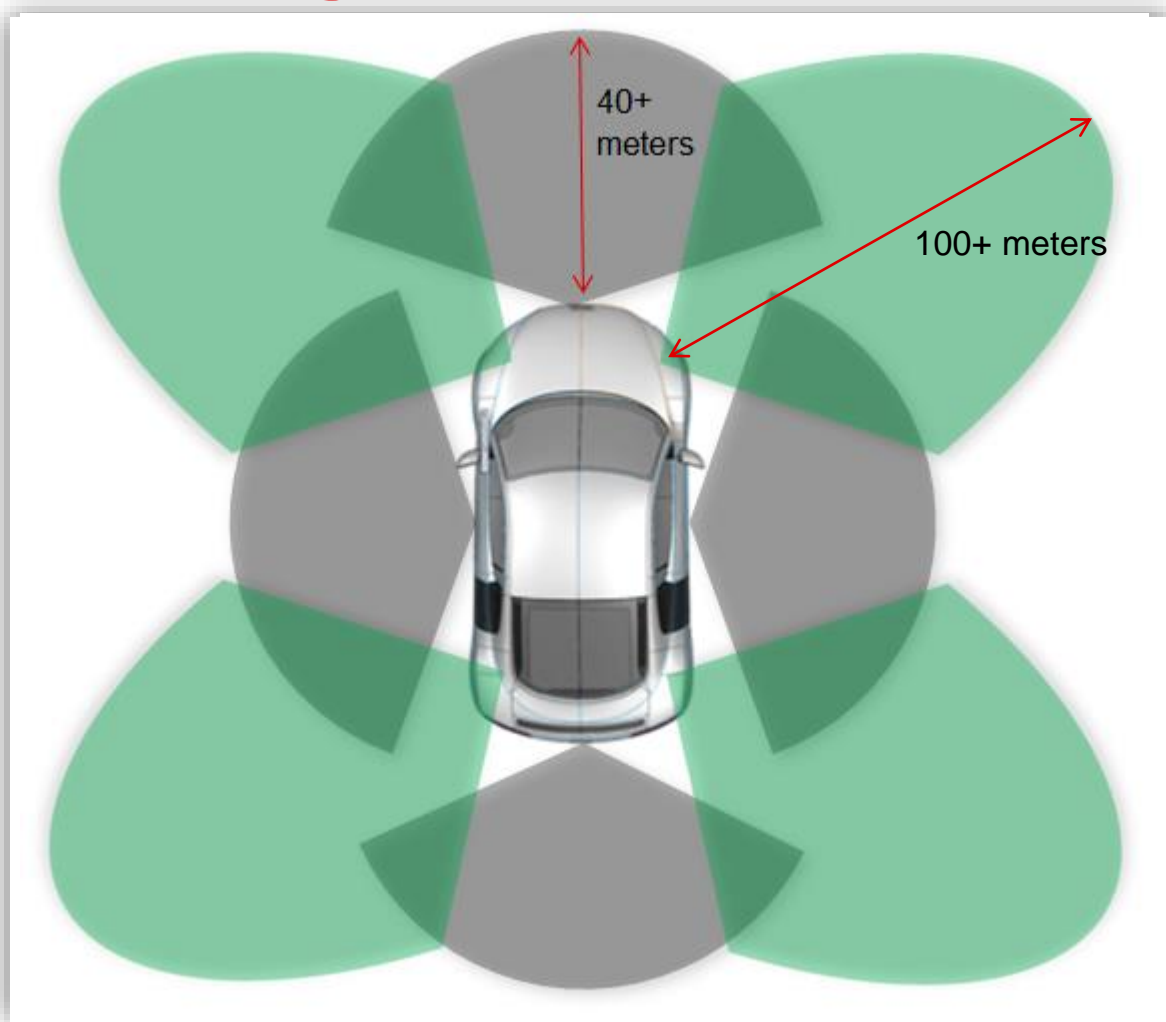
Parking Sensor today



Challenges with Ultrasonic sensors

- ▶ Limited range (15 cm to 5 m)
- ▶ Limited field of view → Need for more number of sensors
- ▶ >12 Ultrasonic sensors cannot achieve 360° coverage
- ▶ Not functional when covered with mud or snow
- ▶ Need to drill holes in bumper

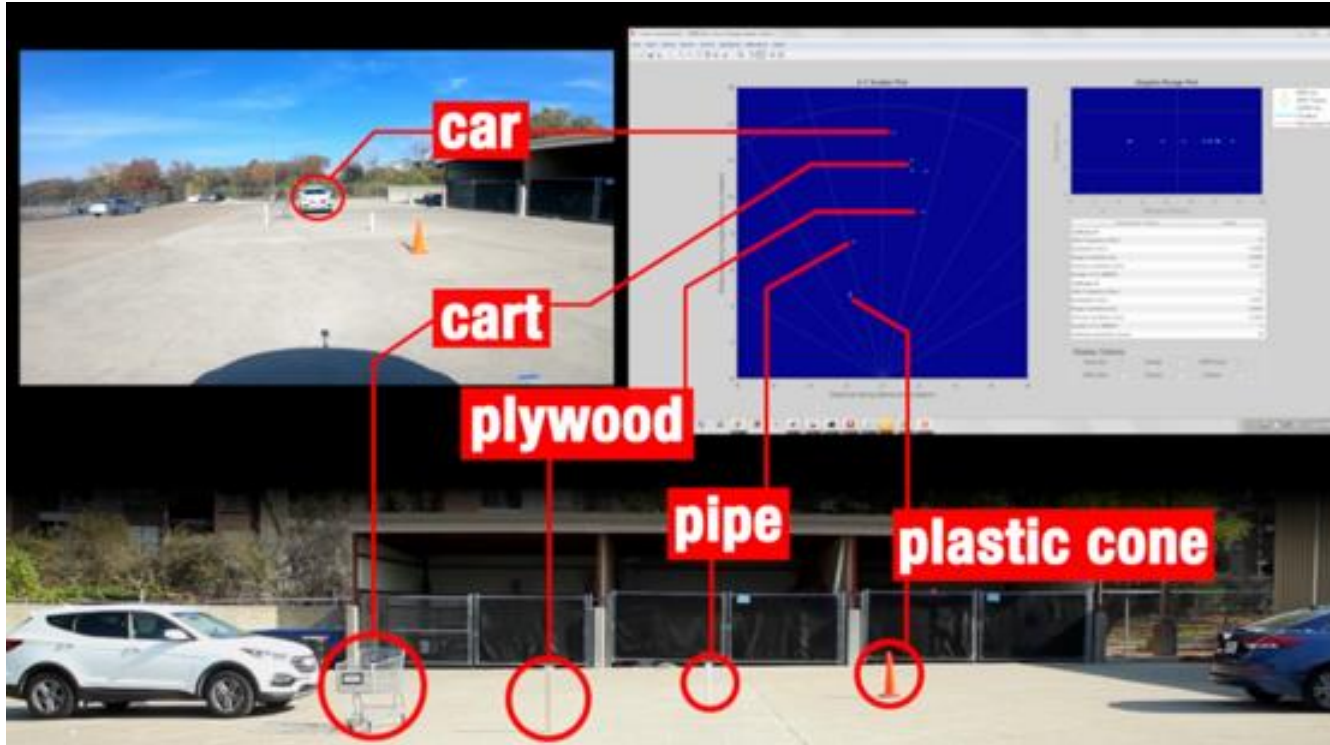
Parking Assist and Corner Radar



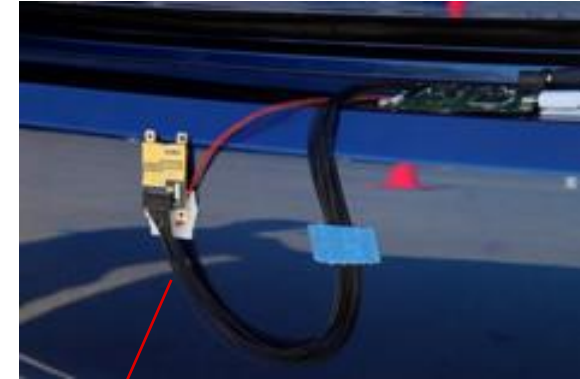
Why Radar for Parking?

- **Extended range** from 10-15 meters to 40+ meters
 - 40+ meters, for high-end parking, can be enabled through AWR1843
- **Wide field of view** (~160 °)
- **Reduced number of sensors** (6-8)
- **Invisible sensors**; No need to drill holes on the bumper
- **Accurate detection** of curb and height measurement
- **Robust** against challenging weather conditions like rain or snow
- **Multi-purpose**: same sensor can be leveraged for other ADAS application
 - Same sensors can also be leveraged for non-ADAS application like kick-to-open, anti-collision sensor for door/trunk.

Example of Parking



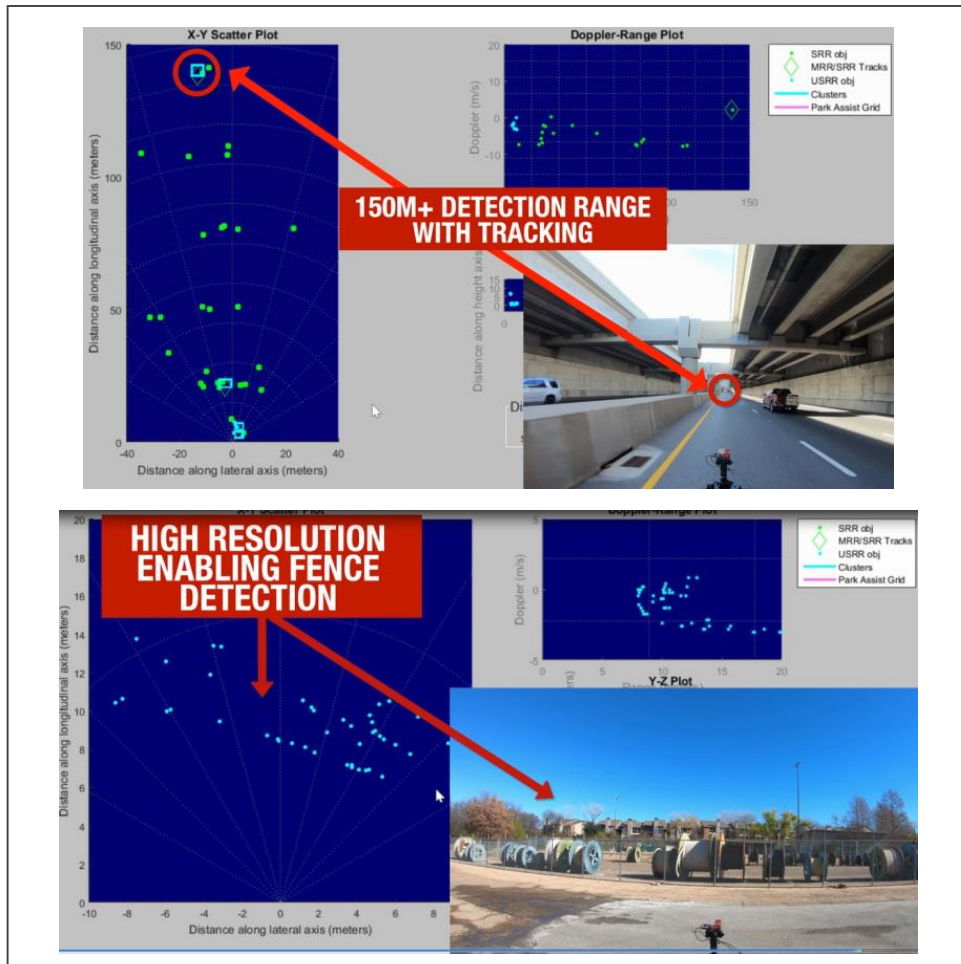
- [Parking demonstration](#) video and [Reference Code](#)



AWR1642 radar module. On car bumper

- Wide FOV
- 40+ m Range
- Multi object detection
- Smallest form factor
- Multi modal/functional

Corner Radar – Using Single Chip Radar Sensor



Key Features

- **Single chip drives smallest form factor & lowest cost sensor**
 - World's first RFCMOS single chip sensor already in production, enabling processing at the edge
- **High precision and accurate detection up to 150m**
 - Ultra-wide bandwidth enables separation of objects as close as 4cm
 - Detection of 200+ objects with multi-mode
- **mmWave-SDK, reference designs and system level learnings enable faster TTM**
 - Safety monitoring, device calibration, optimized power architecture, reference algorithms

Get Started w/ TI Single Chip Sensors for Corner Radars

- [Short range radar reference design](#)
- [Medium range radar demonstration reference source code](#)
- [Automotive reference design with optimized power architecture](#)
- [SRR demonstration video using AWR1642](#)
- [MRR demonstration video using AWR1843](#)

In-Cabin and Near-Field Radar

In-Cabin and Near-Field Sensing Applications



3D Obstacle Detection

Vehicle Occupant Detection

Driver Vital Sign Monitoring

Gesture Recognition

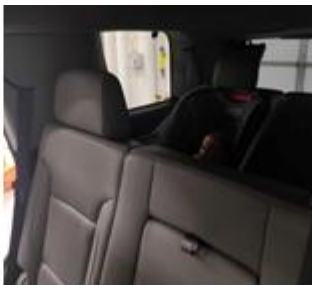
Child Presence Detection tests – Front position



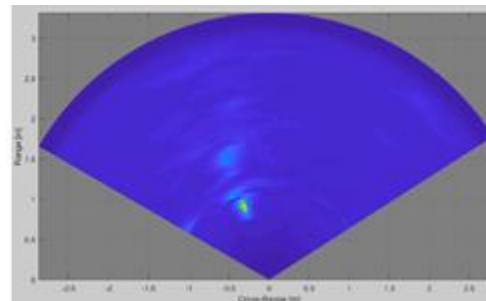
Sensor around Rearview



In 2nd row



In 3rd row



Detection in Range Azimuth

Sensor : [IWR6843ISK](#) EVM (FOV: 120 Azimuth x 30 Elevation)

Car: Large size SUV with 2 rows

Baby doll: https://www.ashtondrake.com/products/301881001_lifelike-breathing-baby-doll.html

Position: Front Position (In front of rearview mirror)

Algorithm: 2D Detection with 2Tx

Advantages:

- Can detect baby in front facing child seat



Child Presence Detection tests – Rooftop position



Sensor in Rooftop



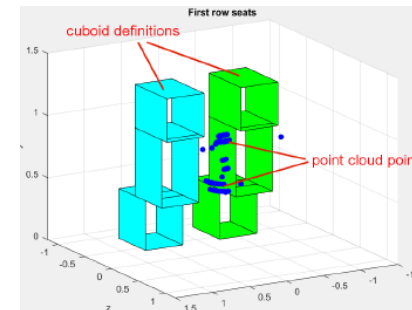
Lying on seat



In Footwell



In baby seat covered by cloth



Detection in Azimuth angle plane

Sensor : [IWR6843ISK-ODS](#) EVM (FOV: 120 Azimuth x 120 Elevation)

Car: Mid size SUV with 2 rows

Baby doll: https://www.ashtondrake.com/products/301881001_lifelike-breathing-baby-doll.html

Position: Roof top/Ceiling (above headrest of 1st row)

Algorithm: 3D Detection in 1 rows (Rear seat)

Advantages:

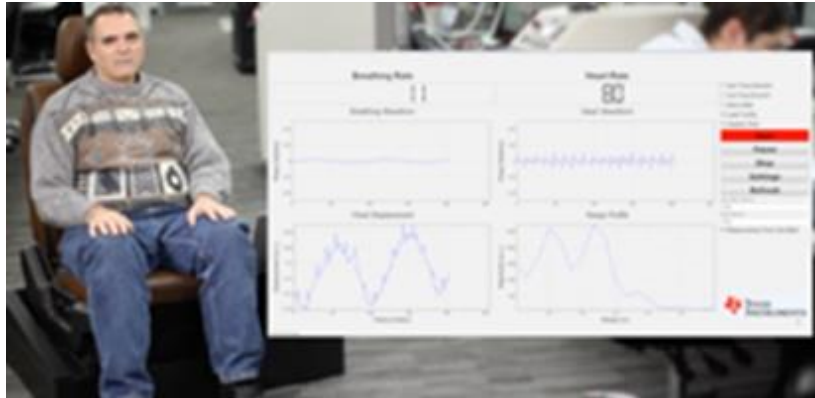
- Can detect baby in footwell, baby in rear facing position
- Can detect adult occupants



Driver Vital Sign Detection



Need for Vital sign monitoring



Sensor inside the seat

Key Features:

- Contactless and non intrusive sensing
- Robust to any environmental conditions

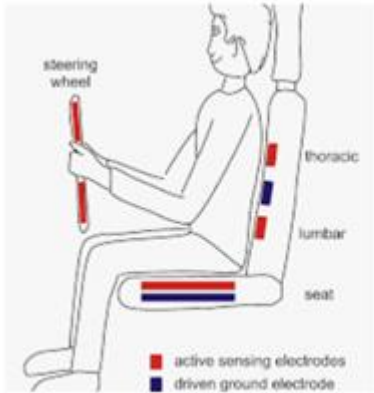
Applications:

- Driver Heart Rate & Breathing rate detection
- Find driver fatigue/sleepy state
- Alert in case of health conditions

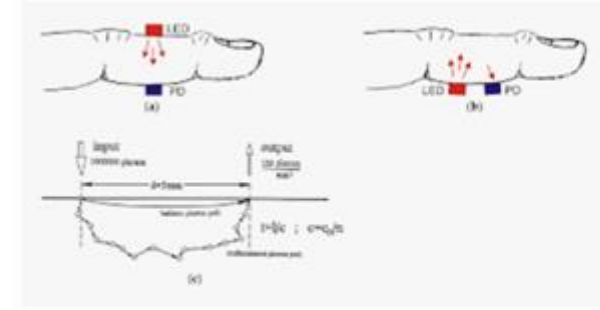
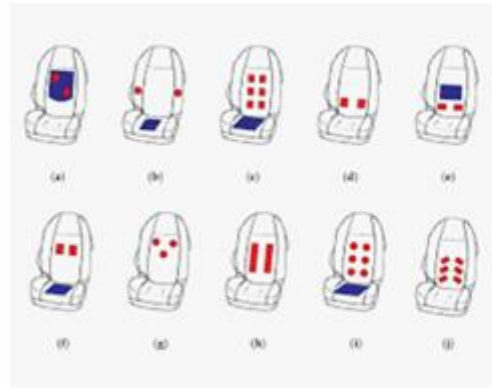
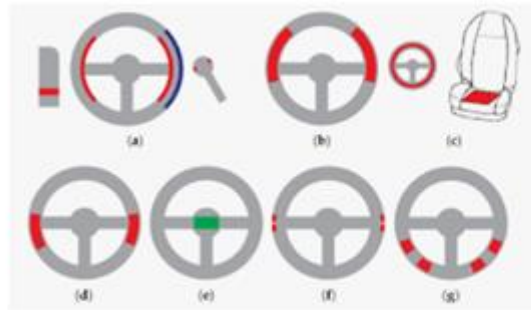
Reference Code:

- Code available on [TI Resource Explorer](#)
- Partner [Video](#) for detection in moving car

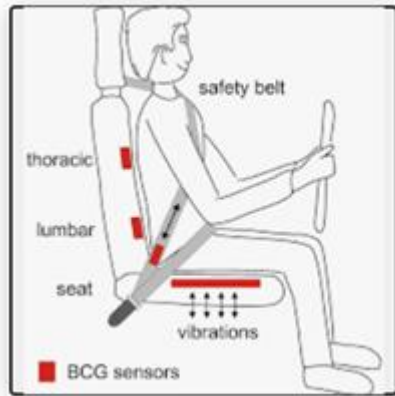
Driver Vital Sign – Technology Review



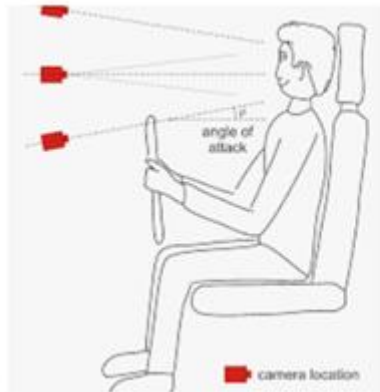
Low Contact ECG



PPG with LED/PD



BCG



Camera



Coil



Radar



Sensor Fusion

Gesture recognition



Key Features

- Multi class gesture detection on single chip sensor
- Enables detection of fine motions with high accuracy
- Not affected by bright light or dark conditions
- Small form factor, can be placed behind plastic

Thank You